TECHNIQUE FOR SENSING ALTITUDE FROM FAN SPEED

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is related to Application No. xx/xxx,xxx entitled, "Utilizing an Altitude Sensor to Control Fan Speed," filed on or about the same date as the present application, and hereby incorporated herein by reference. Application No. xx/xxx,xxx discloses and claims a technique utilizing the altitude calculated from the fan speed in a method to set a fan speed sufficient to allow for proper processor thermal margin.

FIELD OF THE INVENTION

[0002] The present invention relates generally to the field of cooling technologies and more specifically to the field of cooling technologies within a device enclosure where cooling efficiency is related to fan speed and altitude.

BACKGROUND OF THE INVENTION

[0003] As altitude above sea level increases, atmospheric density decreases. This decrease in atmospheric density is responsible for a reduction in cooling capacity of a fan running at a given speed. Since there is less air at higher altitudes, at a given fan speed fewer air molecules will be passing over a heat-generating device, than would be present in the identical system at a lower altitude. This fact presents a problem for designers looking to characterize system requirements, since a given configuration that works well at sea level, may be sufficiently degraded in cooling capacity at higher altitudes such that some electronic devices may no longer be operating within their thermal design margins.

[0004] Designers have typically solved this problem by requiring sufficient cooling of all of their systems for performance at altitude. However, this solution is not optimum for systems operating at sea level, since the same system could operate at a higher frequency at sea level due to the improved air-cooling present at sea level. System performance could be maintained at all altitudes by requiring fans in high altitude systems to run faster, however this requires knowledge of altitude. While it is certainly possible to require users to input altitude information upon first use of a system, this approach is prone to errors. There is a need in the art for a method allowing electronic systems to detect their operating altitude so that they may respond accordingly.

SUMMARY OF THE INVENTION

[0005] A DC fan, or lot of DC fans is characterized at a constant voltage to determine the variation of their rotational speed with respect to altitude. Many such DC fans will have a substantially linear response in speed with respect to altitude. From this relationship, a converter is constructed to convert the rotational speed into an altitude. The converter may be a discrete electronic device including a look up table or capable of performing the arithmetic algorithm representing the relationship between fan speed and altitude. Alternatively, the converter may be incorporated into the system to be cooled by the fan, for example, it may be a software routine run by the computer that the DC fan is used to cool.

[0006] Other aspects and advantages of the present invention will become apparent from the following detailed description, taken in conjunction with the accompanying drawings, illustrating by way of example the principles of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] Figure 1 is a view of a DC fan and converter according to the present invention.

[0008] Figure 2 is a graph showing the relationship between fan rotational speed and altitude in an example embodiment of the present invention.

[0009] Figure 3 is a graph showing the relationship between fan rotational speed and processor thermal margin in an example embodiment of the present invention.

[0010] Figure 4 is a flowchart of an example embodiment of the calculation of altitude from fan rotational speed according to the present invention.

DETAILED DESCRIPTION

[0011] Figure 1 is a view of a DC fan and converter according to the present invention. In an example embodiment of the present invention a DC fan **100** including fan blades **104**, a motor **102**, and an electrical port **108** is provided to cool a heat-generating device. The DC fan **100** may have the ability to output its rotational speed from the fan **100** itself without any additional devices. Alternatively a speed sensor **106**, such as an opto-electronic device that counts fan blades **104** may be used for DC fans **100** without the ability to output their rotational speed. The speed data from the fan **110**, or the speed data from the speed sensor **112** is then input to a converter **114** that converts the speed data into altitude data **116**. The converter **114** is programmed using data obtained by characterizing the rotational speed of the DC fan **100** with respect to altitude. While Figure 1 shows a discrete converter device **114** for simplicity and clarity, other embodiments of the present invention may include the converter function in other electronic devices present in the overall device that is being cooled by the DC fan **100**. For example, in a computer system cooled by the DC fan **100**, the converter functionality may be built in to the processor chip, or may

operate in software under the computer operating system. The physical location and construction of the converter **114** is not critical to the present invention, and the converter **114** functionality may be implemented anywhere desired by the system engineer. A sample of DC fan characterization data is shown in Figure 2.

[0012] Figure 2 is a graph showing the relationship between fan rotational speed and altitude in an example embodiment of the present invention. Since the atmosphere is less dense at altitude than at sea level, a DC fan **100** supplied with a constant power voltage will rotate at a higher rate at higher altitudes. An example graph of this relationship between rotational speed and altitude is shown in Figure 2. In this example graph of a characterization of a DC fan **100**, the horizontal axis **204** represents altitude above sea level, measured in feet, and the vertical axis **202** represents rotational fan speed, measured in revolutions per minute (RPM). In this example embodiment, the characterization data **200** is represented by a straight line. Naturally, most embodiments of the present invention will take fan speed data at a variety of atmospheric pressures related to a variety of altitudes and then a curve will be fit to the data. This curve may be linear in some cases, but other curves may be fit to the characterization data within the scope of the present invention.

[0013] Note that in this example characterization graph, at a first data point **214**,the DC fan **100** rotates at 2500 RPM (represented by point **206** in Figure 2), and at a second data point **216**, when the DC fan **100** is at an altitude of 2000 feet (represented by point **208** in Figure 2). At a higher altitude of 12,000 feet (represented by point **212** in Figure 2), the DC fan rotates at 3000 RPM (represented by point **210** in Figure 2). While this sample characterization data is linear, characterization of other DC fans **100** may result in non-linear characterization data within the scope of the present invention. This characterization data may be described by an arithmetic algorithm, a

look up table, or other equivalent mechanisms or methods for calculation of an altitude when given a fan rotational speed. The resulting characterization data is then programmed into the converter **114** shown in Figure 1.

[0014] Figure 3 is a graph showing the relationship between fan rotational speed and processor thermal margin in an example embodiment of the present invention. As fan speed increases, the amount of air flowing over a heat-generating device also increases. This increased airflow results in more efficient cooling of the heat-generating device resulting in a lower temperature of the heat-generating device. This relationship is shown graphically in Figure 3. In this example graph of the relationship between the temperature of a heat-generating device, the horizontal axis **304** represents the fan speed, measured in RPM, and the vertical axis **302** represents the temperature of the heat-generating device, shown as thermal margin in a processor, and measured in degrees Centigrade (degrees C). Processor thermal margin is the temperature difference between the current temperature of the processor and the maximum allowed temperature. Lower actual temperatures of the heat-generating device result in larger thermal margins. The example thermal data **300** shown in Figure 3 is represented by a straight line, however other embodiments of the present invention may result in non-linear thermal data.

[0015] Note that in this example thermal graph, at a first data point **314**, at a fan speed of 2500 RPM (represented by point **308** in Figure 3), the processor has a thermal margin of 1 degree C (represented by point **306** in Figure 3), and at a second data point **316**, at a fan speed of 3000 RPM (represented by point **312** in Figure 3), the processor has a thermal margin of 8 degrees C (represented by point **310** in Figure 3). Thus, for an increase in fan speed of 500 RPM the processor thermal margin increased by 7 degrees C, which may be critical to processor performance in some designs.

[0016] Figure 4 is a flowchart of an example embodiment of the calculation of altitude from fan rotational speed according to the present invention. In an example embodiment of the present invention, a method of determining altitude from fan speed is begun at a start step **400**. In a preliminary step **402** a DC fan, or a group of DC fans, is characterized to determine their response to altitude as measured by rotational fan speed at a constant input voltage. Note that in some embodiments of the present invention, it may not be necessary to characterize every individual DC fan. Process variations within a given model of fan may be sufficiently small that characterization of a sample of fans from that given model may be sufficient to generate characterization data usable by all fans of that model. In a step **404**, a DC fan speed of a fan is detected. In a step **406**, this fan speed is converted to an altitude by a converter, and the method ends in a finish step **408**.

[0017] The foregoing description of the present invention has been presented for purposes of illustration and description. It is not intended to be exhaustive or to limit the invention to the precise form disclosed, and other modifications and variations may be possible in light of the above teachings. The embodiments were chosen and described in order to best explain the principles of the invention and its practical application to thereby enable others skilled in the art to best utilize the invention in various embodiments and various modifications as are suited to the particular use contemplated. It is intended that the appended claims be construed to include other alternative embodiments of the invention except insofar as limited by the prior art.